Printed Circuit Board Design, Fabrication and Assembly

A. Kandasamy
K.A. Ackley
R.E. Machnowski
R.J. Ryan
K. Wolniewicz

J.A. Mead
R.J. Angona
P.D. Borello
F.C. Densing
D.A. Pinelli
J. Triolo

As the "brains" of sophisticated electronic devices used in experiments throughout the Laboratory, specialized circuit boards are required. These Printed Circuits Boards (PCBs) are exposed to such extreme environments as high radiation, humidity, and cryogenic temperatures in a wide variety of experiments. Circuit boards for these diverse applications are not readily available commercially. Our facility is capable of designing, fabricating and assembling unique PCBs for Instrumentation Division research activities and for other Laboratory programs and activities requiring such specialized circuit boards.

Recent expansion and upgrading of this facility with state-of-the-art equipment has made it an invaluable resource to the Division, for BNL's scientific community, and for our international collaborators.

The Division's PCB design, fabrication and assembly personnel possess the skills and expertise required for realizing many different types of boards. The fabrication facility can prepare multilayer circuit boards with drilled holes of unprecedented accuracy and, with the equipment available, conducting circuit lines in the boards can be made much thinner, and the spacing much closer, than those on commercially mass-produced boards.

Design

The PCB design group has personnel, software, and equipment geared towards fabricating and assembling the circuit boards.

Capabilities

- Schematic entry
- Place and Route.

  Manual place and route.
  Automatic place and route.
- Data translation for artwork generation.
- Generation of data for CNC drilling of boards.
- Photo-plotting (artwork) capabilities.

Software

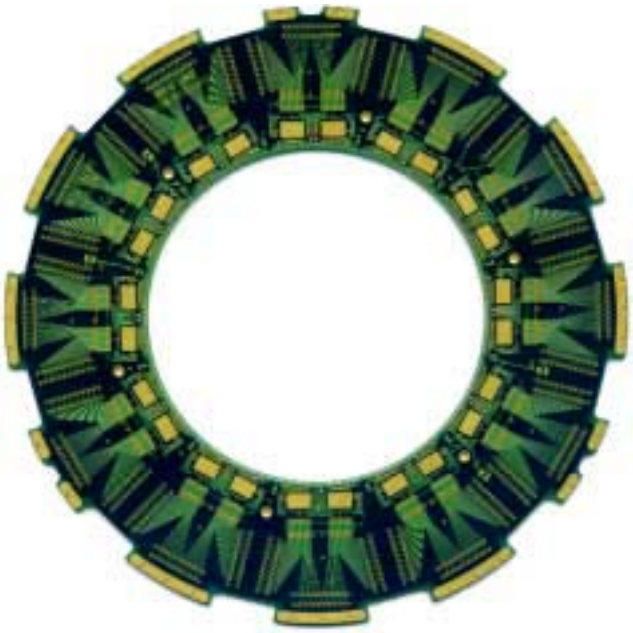
- PADS PowerLogic - Schematic entry
- Viewlogic ViewDraw - Schematic entry
- PADS PowerPCB - Place and Route
- Cadence Specctra - Automatic place and route engine.
- AutoCAD - Computer Aided Drafting
- CAM 350 - Artwork generator and analysis.
- HyperLynx - Signal Integrity analysis.

Equipment

- Cymbolic Sciences F9650 LASER Plotter.
- Optronics L2620 LASER Plotter.
- Kodamatic 66s Photo Processing Unit.

▶ Photo-plotter in the darkroom being loaded with a 26"×20" photographic film for transferring the images from the workstations to the film using a low power laser beam.

Contact:
PC Design Group: A. Kandasamy, (631) 344-5486, anand@bnl.gov
PC Fabrication Group: J.A. Mead, (631) 344-4254, mead@bnl.gov



▲*Seen above is a circular circuit board made for the silicon vertex telescope at the NA45 experiment at CERN. The board houses 24 monolithic circuits that amplifies the signals from the silicon detector mounted in the center of the board.*

Fabrication

The printed circuit board fabrication group produces custom circuit boards from the engineer's initial design to the finished board, with the capability to produce features such as fine holes for via structures and components, ultra fine width and pitch conductive circuit traces. The facility also has the capability to fabricate boards using a wide range of materials like Kapton, Teflon, etc. The facility has an optical inspection station in its process line, which is used for inspecting individual layers for defects such as under or over etched traces, shorts, or opens in traces.

The facility has been and is actively involved in producing prototypes for various experiments for Brookhaven experiments and collaborations. Some of the experiments for which the facility has provided its services are:

- RHIC experiments at Brookhaven.
  - RHIC Beam instrumentation.
  - PHENIX.
  - STAR.
- AGS facility at Brookhaven.
- LHC experiments at CERN.
  - ATLAS
  - NA45

The fabrication facility offers a wide range of services for the scientific community using environmentally safe techniques and equipment, complying with all local, state and federal regulations.

Capabilities

- Multilayer printed circuit boards.
- Rigid-Flex boards.
- Optical inspection of individual layers.
- Computer controlled machinery (drilling, routing) for high precision and repeatability.
- Liquid Photo Imageable (LPI) solder mask and legend.

Equipment

- Dynamotion DM31- Numerically controlled drilling machine capable of hole sizes down to 4±1 mils; programmable Z-axis; drill rate of 200 hits/minute.
- 36" wide Western Magnum Laminator.
- Optibeam and OLEC AP-300 exposure units capable of transferring ultra-fine width and pitch traces to the material using its highly collimated light source.
- Developer and Etcher with pump speed control to vary spray pressure for various line weights; LPI solder mask and legends.
- Camtek 2V30 - Automatic optical inspection station.
- Accudyne - Vacuum-assisted computer-controlled hydraulic laminating press.
- Dynamotion/ATI CNC router.
- Precision oven with temperature range from ambient to 550°F, with fully programmable cycles for preparing the boards for assembly.
- Automated screening machine.
- CVS/SERA analytical equipment for accurate chemical process control.
- Tsunami board cleaner.

▼*Automatic Optical Inspection (AOI) system in operation for detecting faults in circuit board layers.*

▲ *Assembled multilayer printed circuit board is being inspected after the components have been soldered to the board using the surface mount reflow oven.*

Assembly

The circuit board assembly group in Instrumentation is a cost-effective means of assembling specialized custom circuit boards or for performing any kind of rework on existing fixtures or off-the-shelf electronics. The personnel closely integrated into the web of the electronics group in Instrumentation are skilled in the art of assembling electronic components into the circuit boards fabricated either at the facility or elsewhere. The boards prepared by this group then make their way into an experiment or onto an engineer's test bench. The group utilizes a wide range of equipment for assembling large or very small components to silicon die as small as 2 mm × 2 mm with as many as 40 input/output pads in them.

Capabilities

- Through hole and surface mount component assembly (QFP's, BGA etc.).
- Wire bonding for monolithic components.
- Chip on board assembly.
- Custom test fixtures and panel assembly.

Equipment

- OK Industries SMT 8001 - Manual pick and place machine for surface mount component assembly.
- OK Industries KEM 410 - Infra-Red reflow oven for soldering surface mount components.
- Novastar 2000A Convection reflow oven used for soldering large size circuit boards and BGA assemblies.
- Pace TF500 - Circuit board rework station.
- K&S 4123 - Manual aluminum wedge bonder.
- K&S 4526 - Manual aluminum wedge bonder.
- K&S 4124 - Manual gold ball bonder.
- Palomar 2470 - Automated wedge bonding machine with pattern recognition capabilities.
- Dage 4000 - Die and Ball shearing machine and wire pull tester.
- MARCH Plasmod - Plasma cleaner for die cleaning.
- Asymtek C700 - Automatic fluid dispensing system for die encapsulation for chip on board circuits.
- Vision Engineering - LYNX inspection station.
- DataPaq Reflow Tracker – Reflow oven temperature monitoring system.
- Asymtek C700 - Automatic fluid dispensing system for die encapsulation for chip on board circuits.